**Mercury - closest planet to the Sun**

Mercury is the closest planet to the Sun but not the hottest (Venus is the hottest). It is a small rocky planet that looks similar to our Moon because its surface is heavily cratered. However, Mercury's craters are slightly flatter than the Moon's - its stronger gravity may have caused the crater rims to slump more; or erosion may have occurred long ago, if Mercury had a thicker atmosphere in the past. The craters are believed to be mainly from impacts of interplanetary debris during a much earlier stage in the life of our solar system.



Currently, Mercury has an almost negligible atmosphere - only a few billionths of the density of Earth's. The atmosphere consists mainly of sodium vapour, perhaps ejected from the surface by meteorite impacts. There are also small amounts of helium and hydrogen from the solar wind. As for the body of Mercury itself, data from the Mariner 10 spacecraft indicate that this small planet has an unexpectedly large metallic core (probably based on iron) and a rocky crust.

Mercury is much nearer to the Sun than the Earth is, and travels in an oval-shaped orbit. It is normally too close to the Sun to be easily seen from Earth. Even when it is visible, it is not far above the horizon - so the light coming from Mercury has to pass obliquely through the Earth's atmosphere and it is near impossible to obtain a clear image. Also, Mercury's surface is made of relatively dark material and reflects only 11% of the sunlight that falls on it.

Most of the knowledge about mercury comes from the *Mariner 10* spacecraft. It passed as close as 10,000km above Mercury in 1974 and 1975, and the on-board TV cameras took some 4000 pictures which were then transmitted to Earth. The *Mariner* pictures show a large meteorite impact crater called the Caloris Basin (1300km diameter), covering nearly one-tenth of the planet's surface. Another feature that stands out is lines of cliffs (scarps) hundreds of kilometres long. In 2004, NASA launched*Messenger* to Mercury, and it has already made three close ‘fly-by’ passes, preparing to enter orbit around Mercury in 2011. The European Space Agency (ESA) hopes to launch a mission to Mercury in 2012.

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| --- | --- |
| Diameter | 4,880km |
| Surface temperature | -183°C to +427°C |
| Distance to Sun | 45.9 - 69.7 million km |
| Rotation period | 58 days 15 hours |
| Period of orbit | 88 days |
| Number of moons | Nil |

**Venus - the hottest planet**

Venus, the second planet out from the Sun, is also the hottest. It is shrouded in thick clouds made up of tiny droplets of sulphuric acid. On the Earth, the heat-trapping effect of our atmosphere (about 1% carbon dioxide) makes the average surface temperature around 46°C warmer than it would be otherwise. The atmosphere on Venus is 90 times denser than the Earth’s, and around 95% carbon dioxide. This means that the greenhouse effect on Venus increases the surface temperature by 400 degrees or more, making the surface hotter than Mercury.



We can never see through the Venusian clouds, but the surface has been mapped by radar (by space probes and by Earth based stations). Radar scans (e.g. by the ESA *Venus Express* spacecraft) show that 60% of the surface is covered by vast rolling plains, pock marked with craters. Also there are two distinct highland areas which are 4 to 5km higher than the plains which surround them. The highland, known as Ishtar Terra is comparable in size to Australia. The other highland, Aphrodite Terra, is about twice that size and much rougher. Ishtar Terra has the biggest mountain, Maxwell Montes: 11km high (2km higher than Mt Everest). Venus also has a huge canyon 1500km long, 5km deep and up to 400km wide. Hundreds of volcanoes have been found on Venus's surface, and there is evidence that some of them may still be active.

[^ Top ^](http://www.perthobservatory.wa.gov.au/information/venus.html)

Venus and Earth are similar in size, mass and density; but there are important differences. Earth has water and life. Venus is now much too hot for any form of life as we know it, although billions of years ago, before the greenhouse effect made it so hot, it may have had liquid water oceans and even primitive life, just like the Earth. Carbon dioxide makes up almost 96% of the Venusian atmosphere and nitrogen almost 4%. The planet has a hard rocky core, surrounded by a mantle and a thin surface crust.

Strangely, Venus has a retrograde rotation - it rotates “backwards”. It spins east-west while orbiting west-east. When it is approaching Earth, Venus is seen after sunset and known as the “evening star” but when it is moving away from Earth, it appears just before sunrise and known as the “morning star”. Strangely, Uranus and Pluto also have retrograde rotation. The spin and orbit of Venus combine (spin-orbit coupling) in a way that makes a day on Venus equal to 127 Earth days. Venusian daylight lasts 63.5 days, and night lasts 63.5 days!

|  |  |
| --- | --- |
| Diameter | 12,104 km |
| Surface temperature | 460°C |
| Minimum distance from Earth | 42 million km |
| Minimum distance from Sun | 108.2 million km |
| Rotation period | 243 days (retrograde) |
| Period of orbit | 224.7 days |
| Number of moons | Nil |

**Earth - our home in space**

We live on a unique planet named Earth - the only place we know of that has air and water and is able to support life. Earth supports many forms of life - on land, in the waters, and in the air. 70% of the Earth's surface is covered by water. Our air and oceans were formed from gases that seeped from the Earth as it cooled after formation.



We are fortunate to have this type of atmosphere - it is quite dense in the lowest region (up to 10km high) and acts as a filter to shield the surface from harmful rays such as ultra-violet and X-rays. Higher up, it also acts as a buffer zone to protect us from bombardment by meteors: most meteors are vaporized by frictional heating, 85 to 100km above the Earth's surface. The air we breathe is a complex mixture of gases of which only two - oxygen and water vapour - are essential for supporting life.

The Earth has a solid core made up mainly of iron and nickel. The outer part of the core is probably a very dense liquid, surrounded by the mantle and then the crust. When the Earth had just formed, over 4 billion years ago, radioactive material in its interior was generating a great deal of heat. The heat couldn't dissipate quickly enough and the interior grew hotter and hotter, keeping the interior molten and allowing the heavy iron to sink to the centre, forming the core. As the Earth cooled, a thin solid crust formed on the surface, but most of the interior is still either liquid, or under so much pressure that it flows slowly, like plasticine, even though it’s more than hot enough to flow like water when the pressure is released, as in a volcano.

The Earth's extensive oceans, ice caps and cloud cover make it very reflective: it reflects approximately half the energy it receives from the Sun. Seen from space, as the Apollo astronauts saw it in 1969-72, our planet looks very bright: a living, vibrant jewel in space.

|  |  |
| --- | --- |
| Diameter | 12,756 km |
| Surface temperature | -88°C to +58°C |
| Distance from Sun | 149.6 million km |
| Rotation period | 24 hours |
| Period of orbit | 365 days |
| Number of moons | 1 |
| Composition of atmosphere |  |
| Nitrogen | 78.1% |
| Oxygen | 20.9% |
| Argon | 0.9% |
| traces of other gases and water vapour and particles (e.g. dust) |  |

**Mars - the red planet**

Mars is the plant most similar to Earth: it is rocky with a tenuous atmosphere. However, this atmosphere is very thin, with less than 1% of the pressure of the Earth's atmosphere. The Martian atmosphere is made up of 95.3% carbon dioxide, 2.7% nitrogen, 1.6% argon, and traces of other gases. The temperature drops rapidly at night because the atmosphere is too thin to retain the daytime heat. There are polar ice caps, made of water-ice and frozen carbon dioxide, which advance and then recede again as the seasons change. A Martian day is slightly longer than an Earth day (24.6 hours).

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| **Mars (HST image)** |

Mars has been investigated with flybys and landings by the USA, former Soviet Union and the European Space Agency. The first flyby was Mariner 4 from the USA in 1965, which sent back 21 low-resolution pictures. Mariner 9 went into orbit around Mars in 1971 giving detailed pictures of the surface. In 1976 the Viking 1 and Viking 2 missions surveyed Mars in even greater detail with orbiters and landers, and this was repeated again in 1997 with Pathfinder and Sojourner. In 2004, the Mars rovers Spirit and Opportunity landed on Mars. Their design lifetime was only three months, but both are still functioning five years later in 2009. The latest spacecraft to land on Mars, the Phoenix Lander, landed on the 25th May 2008. Its mission was to analyse soil chemistry and weather in the Polar Regions as winter set in. As forecast, increasing cold rendered it inoperable a few months after landing, after it had carried out all of the mission objectives.

[^ Top ^](http://www.perthobservatory.wa.gov.au/information/mars.html)

Rust-coloured sandy desert covers much of the Martian surface, hence the name "The Red Planet". Dust storms are common, with winds of over 200 km/hr. Sometimes a big dust storm will obscure the face of the planet for months. Major surface features include a giant canyon called Valles Marineris (5,000 km long, up to 400 km wide and 7 km deep) and the massive extinct volcano Olympus Mons which is 25 km high and 600 km across at its base.

The first high resolution images of Mars revealed the presence of channels similar to stream beds on Earth. This suggested that water once existed in great quantities on the surface of Mars. Massive quantities of water ice have now been detected from orbit mixed in with the Martian dirt near the surface, like permafrost, even near the equator. Volcanic activity and heat from asteroid impacts in the past have occasionally melted this ice, causing massive mud flows. Mars may also have had a period in the distant past where the early atmosphere kept the entire planet warm enough for liquid water.

In 2011, there will be another NASA mission to Mars with the exclusive goal of looking for signs of life.

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| --- | --- |
| Diameter | 6,786 km |
| Surface temperature | -123°C to +17°C |
| Minimum distance from Earth | 57 million km |
| Average distance from Sun | 227.9 million km |
| Rotation period | 24hr 37min |
| Period of orbit | 1.88 years |
| Number of moons | 2 |

**Jupiter - the gas giant planet**

Jupiter is the largest planet (about 1300 times the volume of the Earth), and the first of the "Jovian" or giant gas planets (Jupiter, Saturn, Uranus and Neptune). These "gas giants" are much bigger and more massive than the terrestrial planets (Mercury, Venus, Earth and Mars), but they are less dense. Jupiter's density is only 1.3 times that of water. Although it is made of light substances, Jupiter is so big that it has three and a half times the mass of all the other planets put together!

Most of our detailed knowledge of Jupiter was gained by the space probes Pioneer 10 and Pioneer 11 in 1973-74, Voyager 1 and Voyager 2 in 1979, and Galileo from 1995 to 2001. Jupiter is made up mainly of hydrogen and helium gas; chemically it is more like the Sun and the stars than like the Earth. There is no solid surface crust. The gas just gets thicker with depth until, deep down, a liquid phase is reached: the liquid molecular hydrogen layer. Much deeper again, under enormous pressure, is the ultra-compressed liquid "metallic hydrogen" interior. At the centre is a rocky core of iron and silicates equal in mass to about 20 Earths. Jupiter's total mass is about 318 Earths.

Apart from the distinctive cloud bands across the face of the planet, the most prominent feature on Jupiter is the Great Red Spot. It measures about 14,000 x 30,000 km and two Earths would easily fit into it! The Great Red Spot has been observed ever since telescopes were invented, about 400 years ago. It is believed to be a huge anticyclone, a high-pressure storm, raging in the Jovian atmosphere.

When Voyager 1 flew by Jupiter in 1979, it searched for rings similar to those around Saturn. A thin, dark ring of material around the planet was discovered, and this was soon confirmed by Voyager 2. In 1995, the Galileo spacecraft arrived at Jupiter and released a probe to study the Jovian atmosphere. Galileo has sent back close up images of Jupiter's moons.

Like the other giant planets, Jupiter has many moons - 66 in all (with more likely to be found). Spacecraft could land on most of these moons because they are solid and made up of rock and ice. Jupiter's four biggest moons (the "Galilean Satellites") can be seen with a small telescope: they are Io, Europa, Ganymede, and Callisto. Ganymede is the biggest moon in the whole solar system, bigger than either Mercury or Pluto. Io, the third largest moon, is one of only three bodies in the Solar System known to have volcanic activity (the other two are Earth and Triton). Europa is considered to be the most likely place we might discover life outside the Earth, as it has been shown to most likely have a liquid water ocean underneath its permanently frozen outer layer of ice several kilometres thick. The volume of Europa's ocean is several times the volume of the combined oceans on the Earth.

|  |  |
| --- | --- |
| Diameter | 142,984 km |
| Minimum distance from Earth | 628.7 million km |
| Minimum distance from Sun | 778.3 million km |
| Equatorial rotation period | 9hr 55min |
| Period of orbit | 11.86 years |
| Number of moons | 66 (+ a ring) |

**Saturn - the ringed giant**

When seen through a telescope, Saturn is the most exciting planet in our Solar System; its beautiful ring system can easily be seen. It is the second biggest planet, with a volume of about 760 Earths. The gas planets all have low densities, but Saturn's density is the lowest in the Solar System: less dense than water. It may have a solid icy or rocky core, but is composed mainly of hydrogen and helium. The outer atmosphere is mainly hydrogen and helium gas, with thick clouds of methane and ammonia. There is no solid surface - the planet is like a vast "sea" of liquid hydrogen and helium, perhaps as deep as 30,000 km.

Saturn's huge ring system may be matter that failed to come together to form a moon when the planet and its present moons were forming. Or the ring material may be from moons that broke up. Perhaps both of these explanations apply. The rings are made up of dust and ice and are more than 270,000 km in diameter, but only about 100m thick.

[^ Top ^](http://www.perthobservatory.wa.gov.au/information/saturn.html)

Before the Voyager probes (1980-81), scientists thought that there were six major rings around Saturn. Voyager data shows that there are actually hundreds, even thousands, of narrow concentric ringlets making up the major rings. The gaps between rings and ringlets are caused by moons that orbit within the gap and clear the area around their orbit, and, by the tidal force exerted by the larger moons.

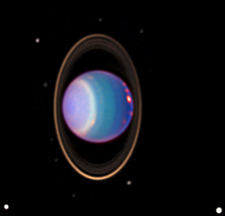
Like Jupiter, Saturn is covered by thick cloud. Also, there are very strong winds, up to 1800 km/hr, near the equator; this is three times the speed of the winds on Jupiter. Huge cyclonic storms occur in Saturn's atmosphere, and there is evidence of lightning discharges. The energy powering all this atmospheric activity comes mainly from inside the planet, rather than from the Sun.

Saturn has more moons than any other planet except Jupiter. The largest moon, Titan, is bigger than Mercury and Pluto. Titan has an atmosphere composed mainly of nitrogen (95%) and denser than that of the Earth. Since 2004 the Cassini spacecraft has made several flybys of Titan and continues to take detailed images of the surface. The Huygens lander that was part of the Cassini mission parachuted down through Titan’s atmosphere in January of 2005. It showed that Titan's surface has liquid methane lakes, rivers, and oceans.

|  |  |
| --- | --- |
| Diameter | 120,536 km |
| Distance from Earth | 1,278.4 million km |
| Distance from Sun | 1,427 million km |
| Equatorial rotation period | 10hr 39min |
| Period of orbit | 29.46 years |
| Number of moons | 62 (+ rings) |

**Uranus**

Uranus, the third of the giant gas planets, is also the third largest planet. Like Jupiter and Saturn it does not have a solid surface and is covered by thick cloud. It was the first major planet to be discovered - that is to say, it was not known to the ancient astronomers. In good viewing conditions, Uranus is just barely visible to the naked eye. It had been overlooked or mistaken for a star until 1781, when William Herschel reported its discovery as a planet.

Uranus is so far away that it cannot be observed in any detail from Earth. It was not until Voyager 2 flew past it in 1986 that we learned what it is really like. We now know that Uranus is mainly made of hydrogen and helium, with thick methane clouds surrounding it. The methane absorbs the red out of the sunlight and makes Uranus look blue-green. There has been no evidence of an internal heat source (unlike the other gaseous planets), and Uranus' distance from the Sun makes it a very cold planet.

[^ Top ^](http://www.perthobservatory.wa.gov.au/information/uranus.html)

In 1977 the ring system of Uranus was discovered by an indirect technique called "stellar occultation". In conjunction with NASA'S airborne observatory, Perth Observatory astronomers detected the rings when Uranus passed in front of a faint star. The star seemed to wink off and on as Uranus' rings interrupted the beam of starlight that was being monitored by the observers' instruments. No actual image of the planet and the rings was obtained; that had to wait until Voyager 2's flyby in 1986. The rings are very narrow and are located at radii of between 39,000 km and 51,000 km.

Prior to the 1986 Voyager 2 flyby, 5 moons were already known, Voyager 2 discovered 11 more, and in between 1997 and 2003, another 11 moons were discovered. Uranus is currently known to have 27 moons with the furthest being Ferdinand orbiting 20,901,000 km from Uranus.

Uranus is very different from the other planets in that it lies nearly on its side; the planet's axis is tilted 98° from the orbital plane instead of being nearly upright like the other planets (Earth is tilted at 23.5°). This means that if you could live near one of the poles of Uranus, the Sun would be visible for 42 years, and then you would be in darkness for the next 42 years of the Uranian orbit around the Sun.

|  |  |
| --- | --- |
| Diameter | 51,118 km |
| Distance from Earth | 2,721 million km |
| Distance from Sun | 2,870 million km |
| Rotation period | 17hr 14min |
| Period of orbit | 84 years |
| Number of moons | 27 (+ a ring system) |

**Neptune - the last of the major planets**

Neptune, the eighth planet out from the Sun, was the second planet discovered by telescope. It is similar in size and composition to Uranus. However, like Jupiter, it gives off more energy than it receives from the Sun. The discovery of Neptune by Joseph Galle in 1846 was a triumph for mathematics: the planet's position had been predicted by Adams and Leverrier in 1845, based on observed irregularities in the orbit of Uranus.



Galileo may have seen Neptune with his rudimentary telescope in 1613, when Jupiter and Neptune were in conjunction. His observing records show a "star" that doesn't appear in modern star catalogues. If indeed Galileo did observe Neptune, this would double the period of time over which it has been observed. One orbit around the Sun takes Neptune 164 years and 280 days, so since its discovery in 1846, it hasn't quite made one complete orbit – it won’t get back around to the same point in the orbit where it was discovered until mid 2010.

[^ Top ^](http://www.perthobservatory.wa.gov.au/information/neptune.html)

Neptune was named after the Roman god of the sea because of its bluish colour. Like all the other gas planets it has a rocky core which is surrounded by a "mantle" of water, methane and ammonia ices. Above the mantle is an atmosphere of hydrogen, helium and methane gases, forming thick clouds. Giant storms rage in the atmosphere. The biggest storm is the "Great Dark Spot" - as wide as the Earth, and similar to the Great Red Spot on Jupiter. The Great Dark Spot had apparently disappeared sometime before 1994 when Hubble was used to observe it. HOWEVER, In 1995 a northern Dark Spot appeared on Neptune.

Neptune has 5 faint rings and 13 moons. The largest moon, Triton, is larger than the dwarf planet Pluto. It orbits the opposite way (retrograde or clockwise) to most other moons in the Solar System. Triton is unlikely to have formed where it is now, orbiting Neptune – instead, it was probably captured by Neptune early in the Solar System’s history.

Neptune's orbit around the Sun is nearly circular. Only Venus has a more circular orbit.

|  |  |
| --- | --- |
| Diameter | 49,528 km |
| Minimum distance from Earth | 4,359 million km |
| Distance from Sun | 4,498 million km |
| Rotation period | 16.1 hrs |
| Period of orbit | 164.8 yrs |
| Number of moons | 13 (+ ring system) |